W. S. THOMSON.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED MAY 20, 1910.

1,009,941.

Patented Nov. 28, 1911.

2 SHEETS—SHEET 1.

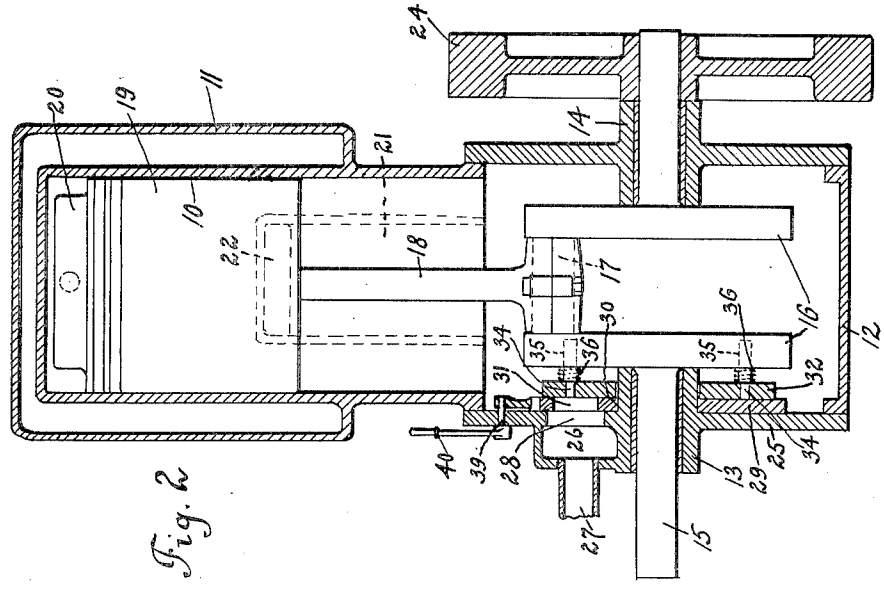

Fig. 2

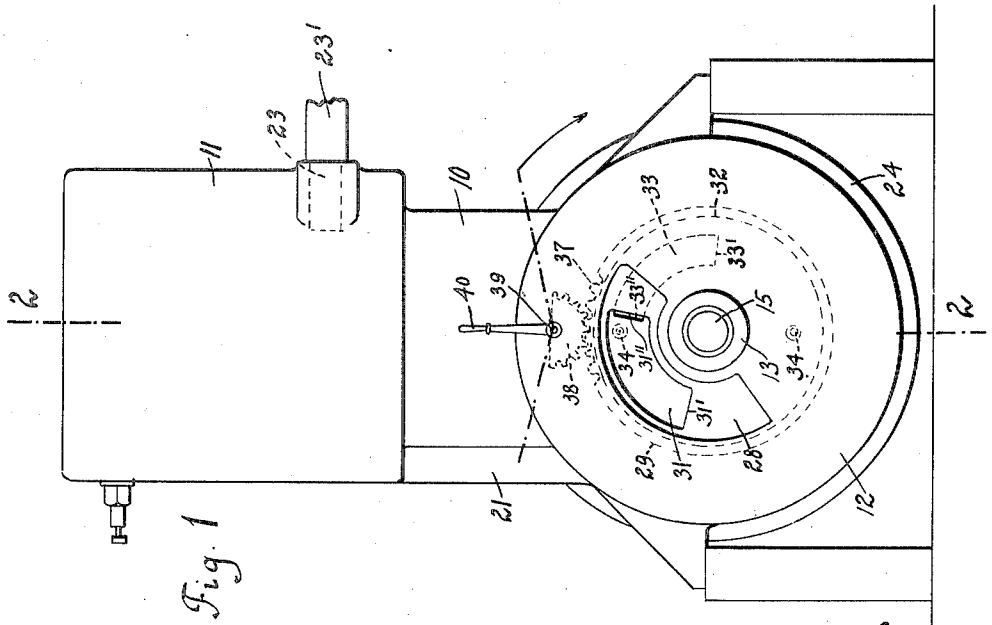

Fig. 1

WITNESSES:

V. Kertész

S. Birnbaum

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INVENTOR

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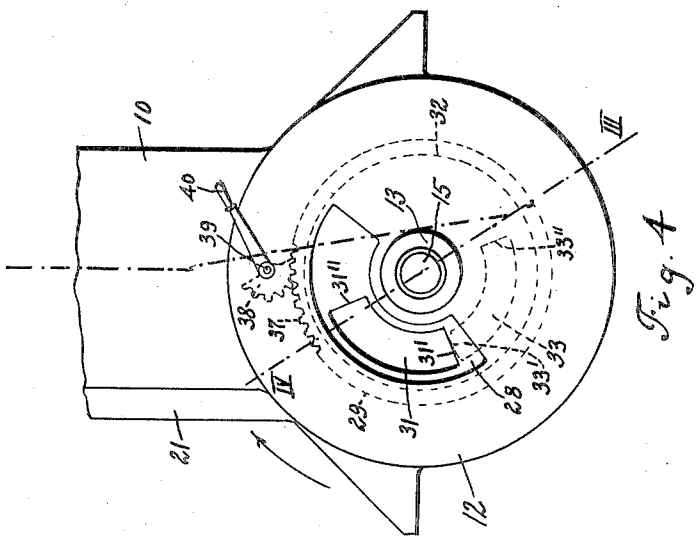

Fig. 4

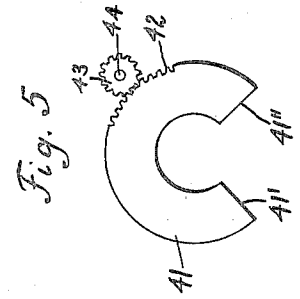

Fig. 5

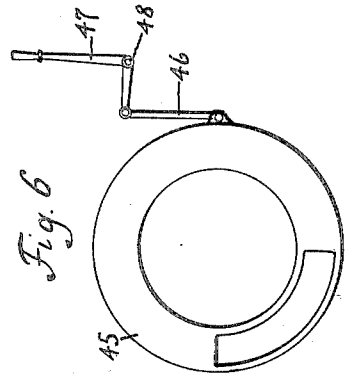

Fig. 6

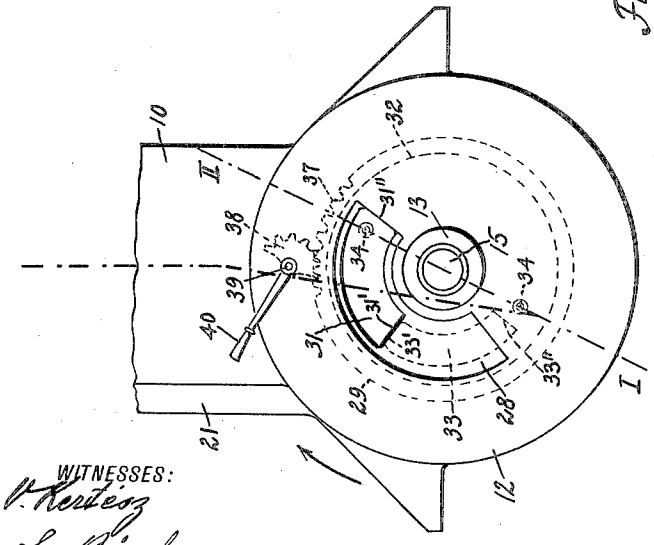

Fig. 3

WITNESSES:

V. Kertesz

S. Birnbaum

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UNITED STATES PATENT OFFICE.

WALTER S. THOMSON, OF NEW YORK, N. Y.

INTERNAL-COMBUSTION ENGINE.

1,009,941. Specification of Letters Patent. Patented Nov. 28, 1911.

Application filed May 20, 1910. Serial No. 562,415.

To all whom it may concern:

Be it known that I, WALTER S. THOMSON, a citizen of the United States, and a resident of the city of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Internal-Combusion Engines, of which the following is a specification.

The present invention relates to improvements in internal combustion engines, and more particularly to means for admitting one or more of the constituents of the combustible charge to the compression chamber of the engine.

Heretofore, as far as known, there have been used for this purpose, among other devices, rotary valves which admit the air or gas during the complete upward stroke of the piston of the engine or during a fraction of travel of the same, but always for a fixed time, whereby the same amount of charge is admitted to the compression chamber of the engine, irrespective whether a light load or a full load is applied to the engine. Obviously it is desirous to admit a carefully throttled charge for light loads, and a greater charge for full loads and high speeds of the engine.

It is one of the objects of the present invention to provide a rotary valve for controlling the admission of the charge to the compression chamber of an internal combustion engine, which allows the amount of the charge or one of its constituents to be varied according to the requirements while the engine is running.

Another object of the invention is to provide a device of this character, which is very simple in construction, efficient and reliable in operation, and which can be constructed of very few parts of simple design and manufactured at a slight cost.

A further object of the invention is to provide a simple means for predetermining and varying, at will, the point of admission of the charge or one of its constituents to the compression chamber of the engine, while the engine is running.

With these and other objects in view, which will more fully appear as the nature of the invention is better understood, the same consists in the construction, arrangement and combination of the parts hereinafter fully described, pointed out in the appended claims and illustrated in the accompanying drawings, it being understood that many changes may be made in the size, proportion and construction of the several parts without departing from the spirit or sacrificing any of the advantages of the invention.

One of the many possible embodiments of the invention is illustrated in the accompanying drawings, in which:—

Figure 1 is a side elevation of an engine constructed in accordance with the present invention, its supply pipe being removed in order to more clearly show certain parts thereof; Fig. 2 is a section taken on line 2—2 of Fig. 1; Figs. 3 and 4 are side elevations of a portion of the engine showing the parts in different positions from that shown in Fig. 1; Figs. 5 and 6 are side elevations of modified means for setting the cut-off valve.

Referring now more particularly to Figs. 1 to 4, inclusive, the numeral 10 designates the cylinder of the engine, having, in the case shown, the usual water-jacket 11, and being mounted upon the crank-case 12, which is provided with the usual bearings 13 and 14, in which the crankshaft 15 is journaled. The webs of the cranks are denoted by the numerals 16, 16. The wrist-pin is shown at 17 and is connected by means of the piston rod 18 with the piston 19, which is provided with the usual deflector 20. A transfer passage 21 connects the interior of the crank-case with the inlet port 22 of the cylinder, opposite to which is arranged the exhaust port 23 from which the exhaust pipe 23′ leads in the usual manner. Upon the crankshaft is mounted a fly-wheel 24 for well known reasons. Thus far the construction and also the operation of the engine does not vary in any essential way from the engines heretofore in use.

Upon the side 25 of the crank-case 12 is arranged a chamber 26, to which leads the supply pipe 27, conducting to the said chamber either the combustible charge, or air if the engine is provided with a fuel injecting device. This chamber communicates with the interior of the crank-case through an arc-shaped opening 28, which extends over an angular distance of substantially 180°, for a purpose to be hereinafter specified. Against the interior side of the wall 25 of the crank-case bears a cut-off valve 29, comprising a disk having a central hole 30, which fits the sleeve constituting the crankshaft bearing 13, and which disk is provided with an arc-shaped slot 31,

adapted to register with the opening 28 in the side of the crank-case. The slot 31 extends through an angular distance of about 90°. Against the cut-off valve 29 bears the rotary valve 32, comprising also a disk having an arc-shaped port 33, which is adapted to register, as the valve is being rotated, with the opening 28 and the slot 31 in the crank-case side and cut-off valve, respectively. This port 33 extends also over an angular distance of about 90°, in the case shown in the drawings, but it is to be noted here that the size and form of the opening 28, slot 31 and port 33 can be varied without departing from the spirit of the invention. The rotary valve 32 carries a plurality of studs 34, 34, in the present case two, which fit into the bores or holes 35 in one of the crank-webs 16. Springs or other resilient means 36 bear against the valve 32 and the crank-web, and tend to force the rotary valve against the cut-off valve, providing thereby a substantially airtight closure therebetween. It will be observed that by means of this construction, the valve 32 is rotated as the crankshaft rotates due to its connection with the piston upon which the products of combustion of the charge act. Upon the periphery of the cut-off valve 29 are arranged teeth 37, meshing with a toothed segment 38, which is pivoted at 39 to some stationary part of the engine and provided with an operating handle 40, located outside of the crank-case.

The operation of the device is as follows: If the slot in the cut-off valve registers with the opening 28 in the crank-case side, the combustible charge or one of its constituents is admitted into the crank case as soon as the opening edge 33′ of the port 33 in the rotary valve passes the opening edge 31′ of the slot 31 in the cut-off valve, and such admission will last until the closing edge 33″ of the port 33 in said rotary valve passes the closing edge 31″ of the slot in the cut-off valve, if the engine is running in the direction of the arrow indicated in the drawings. In Figs. 1 and 2 of the drawings a position of the cut-off valve is shown, which may be termed "the normal or central" position of the same. In this case the combustible mixture or one of its constituents is admitted to the crank-case during the entire upstroke, or in other words during the entire charging stroke of the piston. The admission starts as soon as the piston is in its lower dead center and ceases when the piston is in its upper dead center. In shifting, however, the operating handle 40 to the left and advancing thus the cut-off valve, as shown in Fig. 3 of the drawings, the admission will begin after the crank passes the lower center, and more particularly after reaching the position shown by the dotted line marked I, and the communication between the supply of fuel or one of its constituents and the crank-case will be closed when the crank center passes the dotted line marked II, that is after it has passed considerably the upper dead center. Obviously a full opening of the valve is thus obtained during the time of the most effective vacuum in the crank-case, and this communication is maintained through or during the pause at the upper dead center and through a predetermined downward movement of the piston, whereby the vacuum obtained by the upward stroke of the piston is utilized to the greatest extent.

In Fig. 4 of the drawings, the cut-off valve is shown in its retarded or throttle position, in which case the communication between the charge forming device and between the interior of the crank-case is opened as soon as the crank center reaches in its downward movement the position III, and the communication is closed as soon as it reaches in its upward movement position IV. In this case the valve does not open until after the inlet port in the cylinder has been opened by the piston and the charge previously compressed in the crank-case has been forced up through the inlet port into the cylinder, and the communication is closed before the upper dead center is reached and therefore before the full vacuum has been exerted upon the entering charge or one of its constituents. It will be observed that by means of this construction the admission of the combustible charge or one of its constituents to a two cycle engine can be governed so that the engine can be throttled and run quietly on light loads, and a greater charge can be admitted for full loads and high speeds. While in Figs. 3 and 4 the two extreme positions of the cut-off valve are shown, it will be easily seen that this valve may be set to any intermediate position, and in fact there is an exact angular setting required for every change in speed of a two port two cycle engine, and the only way to obtain the full power and flexibility at all speeds is by means of a valve, the position of which may be changed, at will, while the engine is in operation. The cut-off valve may be set, of course, by hand, or it may be shifted by a governor into the most effective position necessary to the most satisfactory operation of the engine both for speed and power.

A modification of the cut-off valve is shown in Fig. 5 of the drawings, which may be used advantageously for multiple cylinder engines. In this case a substantially horse-shoe shaped disk 41 is made use of, which can be easily mounted upon the crankshaft. The teeth 42 of the disk mesh with a pinion 43, upon the shaft 44 of which are mounted as many pinions as there are cylinders in the

engine and as there are cut off valves 41. The two straight edges 41′ and 41″ of the cut-off valve form the opening and closing edges of the same.

A modification of the operating means of the cut-off valve is shown in Fig. 6 of the drawings, in which case the disk 45 is connected by means of a rod 46 with a bell-crank 47, pivoted at 48 to some stationary part of the engine.

While herein certain relations between the sizes of the three different ports in the crank-case, cut-off valve and rotary valve have been specified, and a particular means for the shifting of the cut-off valve has been shown, it will be easily seen that the relations mentioned may be varied and so also the means for shifting the valves, and the device will still come within the scope of the appended claims, as the invention lies mainly in the combination of a rotary valve with a cut-off valve, irrespective of their location with respect to the crankshaft of the engine.

What I claim is:

1. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary valve having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said chamber, and means for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

2. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary valve having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and means inserted between the wall of said compression chamber and said rotary valve for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

3. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary disk having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and means for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

4. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary disk having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and means inserted between the wall of said compression chamber and said rotary disk for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

5. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary valve having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a slotted disk for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

6. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary valve having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a slotted disk between the wall of said compression chamber and said rotary valve for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

7. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary disk having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a slotted disk for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

8. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary disk having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a slotted disk inserted between the wall of said compression chamber and said rotary disk for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

9. In an internal combustion engine, the combination with the compression chamber

of the engine having an opening in one of its walls, of a rotary valve having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a disk having a slot which extends over an angular distance corresponding to that of the port in said rotary valve for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

10. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary valve having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a disk having a slot which extends over an angular distance corresponding to that of the port in said rotary valve inserted between the wall of said compression chamber and said rotary valve for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

11. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary disk having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a disk having a slot which extends over an angular distance corresponding to that of the port in said rotary valve for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

12. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary disk having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a disk having a slot which extends over an angular distance corresponding to that of the port in said rotary valve inserted between the wall of said compression chamber and said rotary disk for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

13. In an internal combustion engine, the combination with the compression chamber of an engine having an arc-shaped opening in one of its walls, of a rotary valve having a port extending over an angular distance corresponding to half of that of said opening and adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a slotted disk for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

14. In an internal combustion engine, the combination with the compression chamber of the engine having an arc-shaped opening in one of its walls, of a rotary valve having a port extending over an angular distance corresponding to half of that of said opening and adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a slotted disk inserted between the wall of said compression chamber and said rotary valve for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

15. In an internal combustion engine, the combination with the compression chamber of the engine having an arc-shaped opening in one of its walls, of a rotary disk having a port extending over an angular distance corresponding to half of that of said opening and adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a slotted disk for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

16. In an internal combustion engine, the combination with the compression chamber of the engine having an arc-shaped opening in one of its walls, of a rotary disk having a port extending over an angular distance corresponding to half of that of said opening and adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a slotted disk inserted between the wall of said compression chamber and said rotary disk for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

17. In an internal combustion engine, the combination with the compression chamber of the engine having an arc-shaped opening in one of its walls, of a rotary valve having a port extending over an angular distance corresponding to half of that of said opening and adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a disk having a slot which extends over an angular distance cor-

responding to that of the port in said rotary valve for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

18. In an internal combustion engine, the combination with the compression chamber of the engine having an arc-shaped opening in one of its walls, of a rotary valve having a port extending over an angular distance corresponding to half of that of said opening and adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a disk having a slot which extends over an angular distance corresponding to that of the port in said rotary valve inserted between the wall of said compression chamber and said rotary valve for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

19. In an internal combustion engine, the combination with the compression chamber of the engine having an arc-shaped opening in one of its walls, of a rotary disk having a port extending over an angular distance corresponding to half of that of said opening and adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a disk having a slot which extends over an angular distance corresponding to that of the port in said rotary disk for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

20. In an internal combustion engine, the combination with the compression chamber of the engine having an arc-shaped opening in one of its walls, of a rotary disk having a port extending over an angular distance corresponding to half of that of said opening and adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, and a disk having a slot which extends over an angular distance corresponding to that of the port in said rotary disk inserted between the wall of said compression chamber and said rotary disk for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

21. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary valve having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, a slotted disk inserted between the wall of said chamber and said rotary valve, and means for shifting said disk through an angular distance for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

22. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary disk having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, a slotted disk inserted between the wall of said chamber and said rotary disk, and means for shifting said disk through an angular distance for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

23. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary valve having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, a disk having a slot which extends over an angular distance corresponding to that of the port in said rotary valve, and means for shifting said disk through an angular distance for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

24. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary disk having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, a disk having a slot which extends over an angular distance corresponding to that of the port in said rotary disk, and means for shifting said disk through an angular distance for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

25. In an internal combustion engine, the combination with the compression chamber of the engine having an arc-shaped opening in one of its walls, of a rotary disk having a port extending over an angular distance corresponding to half of that of said opening and adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said casing, a disk having a slot

which extends over an angular distance corresponding to that of the port in said rotary disk, and means for shifting said disk through an angular distance for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

26. In an internal combustion engine, the combination with the crank-case of the engine having an opening in one of its walls, of a crankshaft arranged in said case, a rotary valve attached to said crankshaft having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said crankcase, and means for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

27. In an internal combustion engine, the combination with the crank-case of the engine having an opening in one of its walls, of a crankshaft arranged in said case, a rotary valve attached to said crankshaft having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said crank-case, and means inserted between the wall of said crank-case and said rotary valve for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

28. In an internal combustion engine, the combination with the crank-case of the engine having an opening in one of its walls, of a crankshaft arranged in said case, a rotary disk attached to said crankshaft having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said crank-case, and means for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

29. In an internal combustion engine, the combination with the crank-case of the engine having an opening in one of its walls, of a crankshaft arranged in said case, a rotary disk attached to said crankshaft having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said crank-case, and means inserted between the wall of said crank-case and said rotary disk for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

30. In an internal combustion engine, the combination with the crank-case of the engine having an opening in one of its walls, of a crankshaft arranged in said case, a rotary valve attached to said crankshaft having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said crank-case, and means arranged upon said crankshaft for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

31. In an internal combustion engine, the combination with the crank-case of the engine having an opening in one of its walls, of a crankshaft arranged in said case, a rotary valve attached to said crankshaft having a port adapted to register intermittently with said casing and to open thus communication between said opening and the interior of said crank-case, and means arranged upon said crankshaft inserted between the wall of said crank-case and said rotary valve for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

32. In an internal combustion engine, the combination with the crank-case of the engine having an opening in one of its walls, of a crankshaft arranged in said case, a rotary valve attached to said crankshaft having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said crank-case, and a slotted disk arranged upon said crankshaft for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

33. In an internal combustion engine, the combination with the crank-case of the engine having an opening in one of its walls, of a crankshaft arranged in said case, a rotary valve attached to said crankshaft having a port adapted to register intermittently with said opening and to open thus communication between said opening and the interior of said crank-case, and a slotted disk arranged upon said crankshaft and inserted between the wall of said crank-case and said rotary valve for varying, at will simultaneously both the points of opening and closing of said communication relative to the cycle of operation within the cylinder of the engine.

34. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary valve adapted to open and close the communication between said opening and the interior of said chamber during each revolution of the same, and

means for predetermining and varying the opening and closing limits of such communication relative to the cycle of operation within the cylinder of the engine.

35. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary valve adapted to open and close the communication between said opening and the interior of said chamber during each revolution of the same, and means interposed between said opening and said valve for predetermining and varying the opening and closing limits of such communication relative to the cycle of operation within the cylinder of the engine.

36. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary disk adapted to open and close the communication between said opening and the interior of said chamber during each revolution of the same, and means for predetermining and varying the opening and closing limits of such communication relative to the cycle of operation within the cylinder of the engine.

37. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary disk adapted to open and close the communication between said opening and the interior of said chamber during each revolution of the same, and means interposed between said opening and said disk for predetermining and varying the opening and closing limits of such communication relative to the cycle of operation within the cylinder of the engine.

38. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary valve adapted to control the communication between said opening and the interior of said chamber, and means for varying at will the point of opening of said communication relative to the cycle of operation.

39. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary valve adapted to control the communication between said opening and the interior of said chamber, and means interposed between said opening and said valve for varying at will the point of opening of said communication relative to the cycle of operation within the cylinder of the engine.

40. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary disk adapted to control the communication between said opening and the interior of said chamber, and means for varying at will the point of opening of said communication relative to the cycle of operation within the cylinder of the engine.

41. In an internal combustion engine, the combination with the compression chamber of the engine having an opening in one of its walls, of a rotary disk adapted to control the communication between said opening and the interior of said chamber, and means interposed between said opening and said disk for varying at will the point of opening of said communication relative to the cycle of operation within the cylinder of the engine.

Signed at New York, in the county of New York and State of New York, this 17th day of May, A. D. 1910.

WALTER S. THOMSON.

Witnesses:

THOMAS VEITCH,

SIGMUND HERZOG.